Spiky yellow woodlouse *Pseudolaureola atlantica* Ecology and Habitat

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Conservation of the Spiky Yellow Woodlouse and Black Cabbage Tree Woodland

Contents

Background

The Spiky yellow woodlouse (*Pseudolaureola atlantica*), endemic to St Helena Island, a British Overseas Territory, is found in cloud forest vegetation on the High Central Ridge. It is IUCN Red Listed as Critically Endangered, and was estimated to have only 50 extant individuals remaining in a small area of habitat, stimulating the formulation of a project to try to protect the last individuals of the species.
It was believed that *P. atlantica* required the closed canopy and high humidity conditions of black cabbage tree woodland (*Melanodendron integrifolium*), living an arboreal lifestyle on the fern understorey.

Analogous Species

Pseudolaureola is a genus described by Kwon, Ferrara and Taiti (1992) within the Armadillidae, a family of Isopoda (woodlice). There are four species within this genus, found on the islands of St Helena, Madagascar, New Caledonia, and Australia (Schmalfuss, 2003). *Laureola atlantica* was described by Vandel in 1977 before being reassigned to the genus of *Pseudolaureola*.
There has been very little research into this genus, although Judd (2004) found a number of potentially new species in South Western Australia. He also found that tree bark was a niche where woodlouse species were commonly found, including *P. wilsmorei*.
There is an apparently undescribed 'spiky' woodlouse species on St Helena which may be an additional *Pseudolaureola* species and is in need of specific investigation itself.

Figure 1. *Pseudolaureola* species

A *Pseudolaureola wilsmorei* (taken from Judd, 2004), found in South Western Australia (length 4mm)
B Undescribed *Pseudolaureola* species found on High Peak, St Helena (length 3mm)
C *Pseudolaureola atlantica* found on the Peaks, St Helena (length 10mm)

Research on woodlice most frequently focuses on common European species, specifically *Porcellio scaber* and *Armadillidium vulgare*. Knowledge on woodlouse behaviour and ecology is generally based on a few species and is by no mean exhaustively researched; this area of research is not 'glamorous' even within the world of invertebrates. Several common European species of woodlice are present on St Helena, including on the Peaks. Due to the paucity of information, findings from research on *Pseudolaureola atlantica* may have useful applications for other species within the genus or even improve general woodlouse knowledge. Seasonality is a factor affecting European isopod populations (i.e. specific breeding seasons) but is less relevant for species on St Helena and therefore there is likely to be differences in breeding which may impact different aspects of life history (more regular breeding may impact life expectancy) and therefore population dynamics.
Other woodlouse species are also regularly seen on fern fronds, suggesting good climatic conditions for woodlice to live above ground ; other factors than high humidity requirements may be influencing population distribution and spread. This is particularly relevant as some 'expected' *P. atlantica* sites were unoccupied, even close to occupied sites, so other affecting factors need identifying. *P. atlantica* have also been observed at or near ground level, showing that their arboreal lifestyle is flexible.

Previous Knowledge
There has been attention focussed on this species and protection of its habitat at High Peak since at least 2012, including a Fauna and Flora international project and the most recent Darwin Plus project (DPLUS025). Work is generally dependent on projects and continuity can be a problematic linked to funding streams and sustainability. Dissemination of information can also be disjunct and part of the aim of this report is to summarise information and knowledge to date for wider awareness.

Historic evidence
There are historic accounts of people brushing the *P. atlantica* off clothing after a walk through the Peaks (R. Cairns-Wicks pers. comment). This indicates that numbers have seriously dwindled as this is certainly not the case anymore. However, with the creation of wide public walkways less people are likely to encounter individuals, even if they were still present throughout the remaining cloud forest vegetation, reducing detection of remaining subpopulations, although also probably helping to preserve them where they still occur.
The clearance of cloud forest vegetation for flax and pasture creation is likely to have been a key initial factor in their loss, with the surviving population being fragmented and potentially unable to migrate across unsuitable habitat.
Vandel (1977) reported the species only from the High Peak and included dead Tree fern (*Dicksonia arborescens*) trunks, *Diplazium* (filamentosum) and St Helena Dogwood (*Nesohedyotis arborea*) as vegetation where it was found. This is why previous work has focussed on the Dell, on High Peak. Numbers here appear to have dramatically reduced; individuals were seen previously on surrounding vegetation (H. Mendel pers. comment, R. Cairns-Wicks pers. comment), but sightings in the Dell are now low, with a maximum of 12 individuals located in one search period. This subpopulation may be greatly reduced, individuals in this area may be highly mobile and occur on vegetation outside the Dell itself, or a combination of these.
While work in this area has provided useful ecological information, the rediscovery of other extant subpopulations has made the conclusions on habitat requirements based solely on this site inaccurate. However, there may be some differences in preferences of the populations in different areas. Black cabbage tree woodland, the focus of previous research, is a scarce habitat, and as individuals and subpopulations have now been found on different plant species in different localities, including non-natives, a wider, more general approach is now needed.

Surveying

Surveying and research on this species presents a number of challenges; the terrain is difficult, the endemic plant species are delicate, the ground is prone to erosion and the *P. atlantica* themselves are difficult to see on the vegetation.

Methods undertaken:

1. Single searches of areas
   This included general habitat searches, and searches with standardised point counts
2. Repeat transects
   Four areas of known *P. atlantica* presence were utilised for repeat transects, to monitor these areas for changes, impacts of disturbance, and vegetation assessment
3. UV searches
   General night searches were undertaken, with areas of *P. atlantica* presence noted
4. UV night counts
   A repeat of daytime survey methodology was undertaken at night with a UV torch to gain better understanding of differences in daytime detection and actual numbers (Figure 2)
5. Static observations
   P. atlantica were observed for extended periods during day and night to gain further insight into their behaviour

Figure 2. *P. atlantica* under UV light

Key finding

P. atlantica fluoresce under ultraviolet (UV) light (Dutton & Pryce in press; Figs 2 & 3). Individuals are more easily detected using this method and this has provided greater insight into their true population numbers and distribution. The UV torch also allows for a more confident assessment of presence or absence with thorough inspection of the vegetation.

Figure 3. Comparison of detectability in white and UV light

Areas

While initial work was undertaken on High Peak, locations of *P. atlantica* presence have also been identified on the main tract of the High Central Ridge (Cuckholds, Actaeon and Diana's Peaks) (by DPLUS029; Havery *et al.,* 2016). High Peak and the rest of the High Central Ridge (referred to as Diana's Peak) are separated by several kilometres and while once were linked by cloud forest vegetation, High Peak has now been isolated for a substantial amount of time. It is not yet clear whether the subpopulations in these areas have been isolated for long enough for genetic differences to occur. This should be investigated prior to any work where individuals may be moved (e.g. translocations or captive breeding).

Work has focussed on accessible areas on both Peaks areas. Many of the areas where *P. atlantica* is presence, particularly the endemic trees, are down steep banks through thick vegetation. This makes aspects of work, particularly night work, difficult and this work was limited to safely accessible areas. This limits conclusions and the extent of current knowledge but inferences can still be made and worked on in the future.

Habitat

Individuals were originally believed to require the high humidity of a closed canopy, and live on fern species, particularly Black scale fern (*Diplazium filamentosum*) (Havery *et al*., 2016). During recent surveys, numerous individuals have been found on tree fern (*Dicksonia arborescens*), both in areas with a higher tree canopy (most commonly black cabbage tree, dogwood, or bilberry tree) and also in areas with no other tree canopy. Presence of *P. atlantica* on tree fern has been found more frequently than presence on Black scale fern; these findings may be influenced by the presence of tree fern over black scale fern, the ease of searching tree fern fronds at head height compared to thick, waist height black scale fern fronds, the number of searches in each habitat type, or may reflect higher individual density on tree fern than Black scale fern.

Figure 4. *P. atlantica* habitats

(a) Tree fern (b) St Helena Dogwood (c) Black scale fern

Some rare endemic cloud forest tree species have been found to harbour high densities of *P. atlantica*, including individuals of St Helena dogwood, Whitewood (*Petrobium arboreum*) and He cabbage (*Pladaroxylon leucodendron*). These are generally found above 750m within tree fern thicket and invasive species stands. These tree species are rare therefore *P. atlantica* presence on these is difficult to assess or directly compare. It may be that historically this woodlouse was present across cloud forest vegetation and these remnants represent contractions of undisturbed habitat.

P. atlantica are present on vegetation under a canopy, but are also frequently seen on canopy foliage and emergent vegetation exposed to high winds (Table 1). This species is most commonly seen between one to two metres off the ground, but have been noted throughout the vegetation, from ground level (most often at night) to canopy over 3m above ground level. It is difficult to fully assess the vegetation in areas where *P. atlantica* are present, due to the steep terrain, thickness of vegetation and sensitive nature of the vegetation. Therefore their presence islikely to be underestimated in the less accessible areas. The current population estimate of 980 individuals

may be altered by findings through future work, and longer term monitoring which will provide more information on the stability and viability of current subpopulations.

Table 1. Vegetation *P. atlantica* have been found on

Location	Frequency
Underside of live tree fern	Most sightings
Dead tree fern frond or rachis	Occasional
Underside of black scale fern	Regular
Stipe of ferns	Regular
Underside of dogwood leaves	Most tree sightings
Underside of whitewood leaves	Occasional
Under spider webbing on leaves or fronds	Occasional
On bark of Dogwood	Occasional
Underside of He cabbage leaves	Regular on 3 specific trees
Underside of Bilberry leaves	Occasional

Individuals have now been found next to some parts of the Peaks pathways and in areas where vegetation is being actively managed, suggesting that disturbance does not negatively affect their presence in the short to medium term. This provides a useful, accessible option for monitoring, although it is clear that difficulties in terrain will limit the ability to estimate the true extent of this species.

A key habitat concern is the invasion of non-endemics, particularly Whiteweed and Fuchsia (*Fuchsia coccinea*) on Diana's Peak, where native vegetation may be lost without intervention. However, this does not necessarily mean that *P. atlantica* are excluded from areas where all native plant species have been lost. The number of plant species *P. atlantica* have been identified on has been greatly increased in recent research (Table 2). While there have been limited numbers seen on some of these additional species, this work shows that *P. atlantica* are not specific to particular species or group of vegetation.

Table 2. Plant species *P. atlantica* observed on

Endemic	***Non-native***
St Helena tree fern (*Dicksonia arborescens*)	[1]Bilberry tree (*Solanum mauritianum*)
St Helena Dogwood (*Nesohedyotis arborea*)	[1]Whiteweed (*Austroeupatorium inulifolium*)
Whitewood (*Petrobium arborium*)	[1]Bramble (*Rubus pinnatus*)
He cabbage (*Pladaroxylon leucodendron*)	[1]Flax (*Phormium tenax*)*
Black scale fern (*Diplazium filamentosum*)	
Brown scale fern (*Pseudophegopteris dianae*)	
[1]Sickle fern (*Asplenium platybasis* var. *platybasis*)*	
[1]Plastic fern (*Asplenium compressum*)*	

*Single observation or night sighting [1]First seen 2016/17

While *P. atlantica* are present on ferns under a black cabbage tree canopy, no individuals have yet been seen on black cabbage tree despite a number of searches with UV light in areas of high *P. atlantica* and black cabbage tree density. Therefore we are confident that *P. atlantica* are not regularly present on this species. This is particularly interesting due to Black cabbage tree being the most common native tree species on the Peaks, and may have impacts on restoration planning for this species in particular.

Figure 5. Black cabbage tree woodland with black scale fern understorey

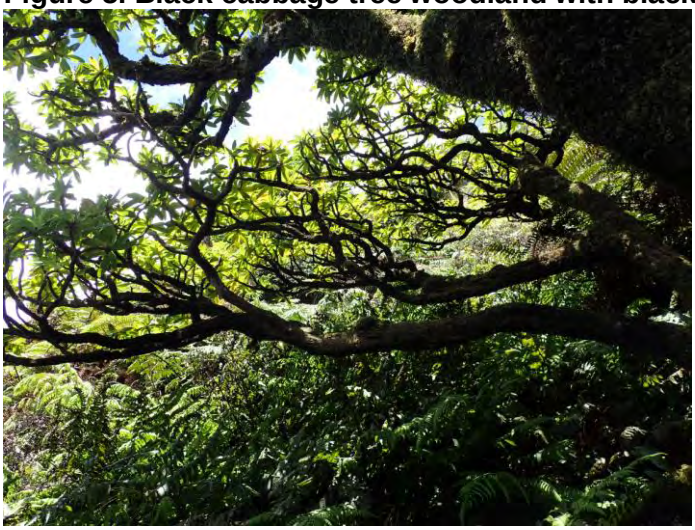
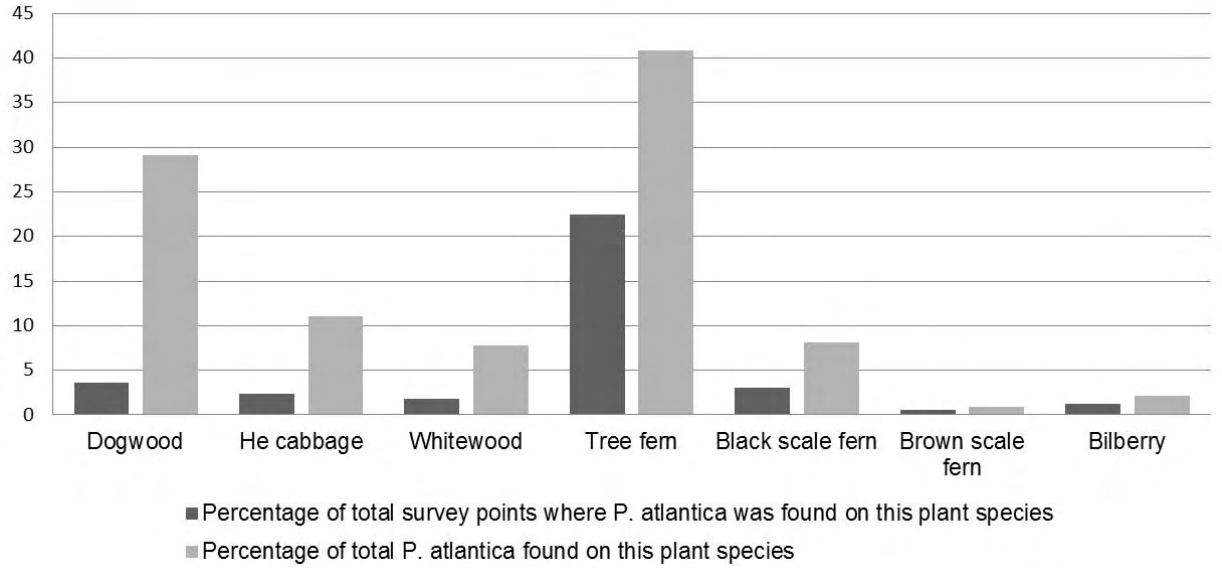


Figure 6. Spiky yellow woodlouse presence on vegetation during day surveys



Behaviour

While woodlice are noted to be primarily nocturnal (Sutton, 1972), *P. atlantica* can be active during the day. Activity is generally short and sporadic, often only moving a short distance along a tree fern frond and returning to a similar location before becoming stationary again. Some individuals cover much larger distances during day or night activities, but influencing factors or stimuli are unclear.

Mostly there is little interaction between individual *P. atlantica* on fern fronds. Individuals are in closer proximity on leaves with a smaller surface area (i.e. dogwood leaves over a tree fern frond) but direct interaction was limited during observations. Congregations may be due to the conditions on the leaves, smaller area, or potentially some other factor. On High Peak although there are Dogwoods present, these hold far fewer *P. atlantica* than areas of Dogwoods on Diana's Peak where occupancy is high. Most Dogwoods on High Peak are younger and smaller, but even the mature Dogwood next to the Dell holds few *P. atlantica*. Individuals on Dogwood on Diana's Peak were mainly stationary during the day, and this location was not visited during night due to access difficulties and the high likelihood of damaging vegetation. Individuals on tree bark rarely moved during observations, while those individuals seen on the ground were always mobile, moving until they encountered vegetation to climb up, although one individual did withdraw under the leaf litter and could not then be relocated. *P. atlantica* will 'rest' on other

substrates, including rock, with a small population previously recorded residing in a small 'cave' on High Peak, although this subpopulation now appears to have been lost.

Mobility
Mobility of individuals is very variable. Activity increases at night, and it is likely that the majority of interactions and movement occurs during this time as with other woodlouse species (Sutton, 1972). Some individuals only travel a short distance over several days, but an individual may move several metres or more in a single night. Numbers of *P. atlantica* appear to be similar in areas revisited over several weeks but this may be regular movement of a number of individuals and/or static individuals. Greater movement may be a response to changes in the vegetation or conditions. Fern frond leaves appear to be relatively short lived (several weeks) so individual *P. atlantica* must be active enough to move between fronds of different ages.

Population structure
All surveyed locations revealed individuals at varying sizes. This indicates a dynamic population but assessing the breeding population and mortality rates is more difficult.

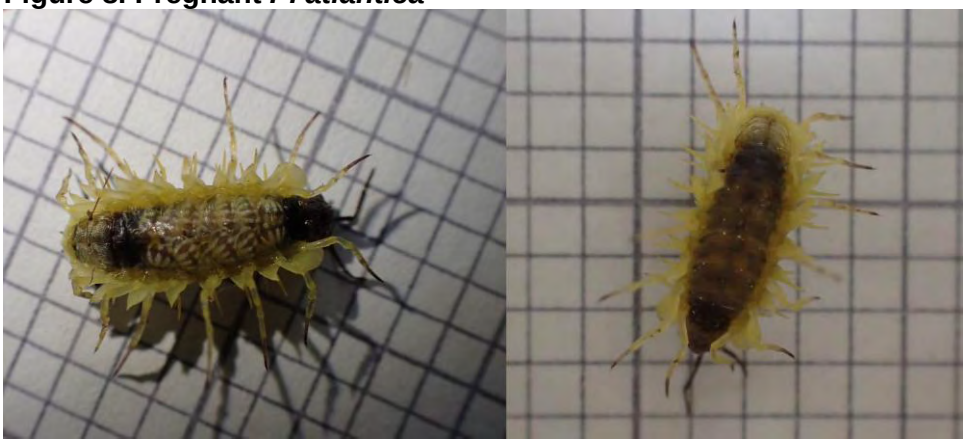
Figure 7. Groups of *P. atlantica*

Life history
Not much is known about the life history of this species. Growth rate, fecundity, mortality and life expectancy, all vital elements of a species' life history are unknown and difficult to determine in the field. Previous research suggested that individuals may shed their exoskeleton as regularly as every two weeks (P. Lambdon pers. comment), with there being at least seven stadia during development. Exoskeleton was found regularly during surveys. Other woodlouse species live for two to five years (Hassall *et al*., 2003).

Reproduction
It is likely that, as with other isopods, mating occurs at night, and is easily disturbed by light (Sutton, 1972). Red light was used during night observations and appeared not to disturb natural behaviours.
After fertilisation, the eggs are transferred into a brood pouch which females develop after moulting. Young develop within this pouch, for approximately one month in *P. scaber* (Hassall *et al.* 2003), before emerging. Breeding of *P. atlantica* was previously considered to occur in the winter on St Helena (P. Lambdon pers. comment), but pregnant females have now also been seen in November and January, with a new brood of emerged juveniles also seen in February, suggesting year-round breeding. This is also consistent with the range of sizes of individuals often present in a location. The age for sexual maturity is currently unknown, it is likely that larger females are more successful at producing a brood and but males may be mature at a smaller size. Isopod fecundity is related to size (Hassall and Dangerfield, 1990) and it appears that only

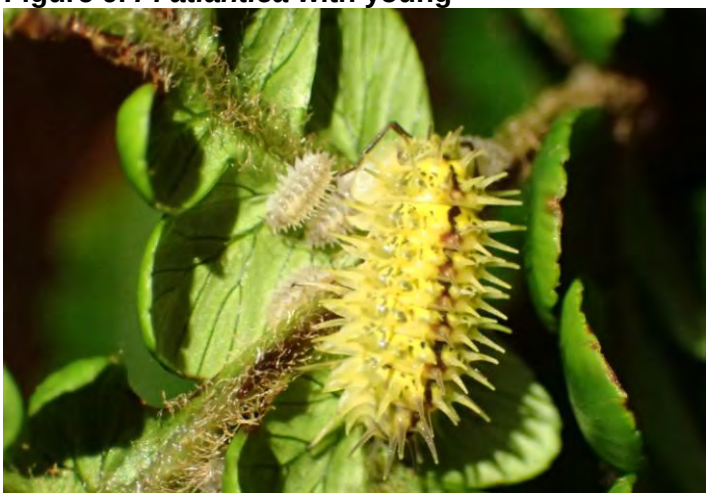
large females over 9mm breed in *P. atlantica*. Brood size is between six and nine individuals, although potentially up to twelve could being accommodated in the brood pouch.

Figure 8. Pregnant *P. atlantica*



Short term handling of pregnant females did not negatively affect these individuals as they were observed after being replaced and moved normally once returned.
There may be an element of parental care after the young emerge, as observations of two adults with a group of very young (likely newly emerged) *P. atlantica* showed increased activity and limited initial dispersal. There was also increased interaction between the adults, possibly the emergence of young indicated a newly receptive female. Limited physical information can be gathered at this stage and during these observations without disturbance which would alter interactions. Also, locating young is difficult; very young *P. atlantica* do not fluoresce, and pregnant females if found can still travel beyond the observation location before the young emerge.

Figure 9. *P. atlantica* with young



Feeding

With few exceptions woodlice are commonly detritivores, eating decaying organic matter (Paolett and Hassall 1999) with specific microbe ingestion also occurring (Ihnen and Zimmer, 2008). Due to *P. atlantica* habitat being above ground, where there is little detritus available and alternative feeding strategies must be assessed.
P. atlantica are opportunistic and will feed on detritus when found. They have been observed feeding on unidentified detritus (possibly black cabbage tree flower), snail excrement, and shed exoskeleton. It is likely that they feed on algae or fungi present on the surface of leaves and fern fronds; they have also been seen moving their mouthparts against the hairs on the surface of the

fern rachis. Feeding occurs during the day as well as at night. Videos of feeding behaviour have been made to enable closer scrutiny; the field camera used (Olympus Tough TG-4) had a microscope setting that allowed for very close focus, closer than was possible by eye, without seeming to disturb the individuals. Woodlice have been found to feed on microbes and fungi (Ihnen & Zimmer, 2008) and this is likely to be a foodsource available to *P. atlantica;* the Dogwoods on Diana's Peak in particular were found to have a number of substances on the leaves. *P. atlantica* have also been known to visit Redwood flowers, possibly for nectar or pollen (R. Cairns-Wicks pers. comm).
It is considered that the *P. atlantica* is a generalist feeder (also supported by its presence on different plant species) and this species will take a range of available foodstuffs.

Figure 10. *P. atlantica* feeding

(a) Snail excrement (b) Active mouthpart movement on rachis (c) Detritus

Defecating has not been regularly observed but appears to be ejected away from the substrate. While this may not provide an opportunity for copraphagy seen in other isopod species (Paolett and Hassall, 1999), this may be undertaken to avoid a build-up of faecal matter on occupied areas, which may indicate their presence to potential predators.

Variation

There can be colour variation between stadia. Medium sized juveniles can be darker, although all individuals over 8mm appear to have the typical *P. atlantica* colouring. These differences do not appear to be linked to shedding of the exoskeleton as they varied between individuals about to shed and those not. Location also seemed not to affect appearance.
Females seem to vary in brightness more than males, however young males may be more easily misidentified as females until external characteristics are sufficiently developed.

Figure 11. Different stages of *P. atlantica* growth

Individuals sometimes display deformities, particularly to the epimeron of the first pereionite. This included missing projections and bulbous features. Occasionally a limb was or antennae was also missing. These did not seem to affect mobility, although their ability to shed the exoskeleton around these features may impact on their survival, if it causes difficulties. Again, this would be difficult to monitor but could be investigated in the lab with other woodlouse species for a estimate of impact.

Figure 12. *P. atlantica* deformity

Other Species

Other woodlouse species are often around where *P. atlantica* are present. These include *Oniscus asellus*, *Porcellio scaber*, *Littorophiloscia alticola* and *Atlantoscia floridana*. Another, apparently undescribed *Pseudolaureola*, much smaller (up to around 4mm) is also found on High Peak. This is present on the fern fronds but also in the leaf litter. There are limited interactions between individuals of any species.

There are two genera of woodlouse spiders found on the Peaks, the non-endemic *Dysdera crocata* and at least three species in the endemic *Tecution* genus. Dysdera appears to occupy the ground-living niche, with *Tecution* present in the vegetation (Mendel *et al*., 2008). *Tecution* is likely a natural predator of *P. atlantica*, potentially even taking adults, although this activity is very difficult to observe in the field.

Rats and mice are present across the Peaks, as well as other areas of the island. Rat damage has been seen in areas of Tree fern thicket across the Peaks, including *P. atlantica* areas. While direct predation is unlikely unless an individual is on the ground, damage to the habitat may affect *P. atlantica* populations.

In areas of *P. atlantica* presence, other rare endemic species including the Golden sail spider (*Argyrodes mellisi*) and the Ammonite Snail (*Helenoconcha relicta*) also occur. This shows that *P. atlantica* is a good flagship species for other rare cloud forest invertebrates, and for the preservation of the habitat itself.

Conservation Needs of *Pseudolaureola atlantica*

The Spiky yellow woodlouse has been found to be more common than initially feared, now that less accessible areas of the Peaks have been visited. These may reflect remnant populations where they occur with isolated endemic trees, which would still be a cause for concern, but individuals have now also been found between these locations, and many have been found in more widespread tree fern thicket. While it is reassuring that this species occupies different areas, there are still unoccupied areas of apparently suitable vegetation, for which the reason is unclear, particularly areas with a population nearby. Until its needs are more fully understood, its true distribution cannot be effectively assessed.

It is believed that with sympathetic habitat management to maintain high quality cloud forest vegetation, this species may be capable of colonisation of currently unoccupied areas. However, further investigation into their ecological requirements, along with monitoring of long term population fluctuations and stability is needed to determine if these populations are stable and likely to persist. High densities found in endemic trees could be acting as sources for the surrounding habitat, but equally may be population sinks, with individuals congregating in these areas and lower migration therefore occurring. It is more believed to be more likely that these areas are acting as source populations, particularly as there reproduction clearly occurring in these areas and individuals are found in surrounding vegetation. In most areas juveniles are seen

along with adults, indicating breeding populations, although survivorship is unknown and specific predators have not been identified.
There may be some differences between preferences of *P. atlantica* between High Peak and Diana's, or conditions differ slightly, or historic habitat differences are present. While St Helena Dogwoods appear a popular host plant on Diana's Peak, *P. atlantica* are less often found on this species on High Peak. This is an interesting area to undertake further research to establish the needs of not just the population, but the isolated subpopulations.
Maintaining and enhancing areas of connected cloud forest vegetation, with varying species composition but including a variety of endemic ferns and trees, is likely to be of greatest benefit to this species. Individuals have been seen to persist in areas of disturbance therefore management is not likely to be intrinsically negative to populations present.
While a captive breeding programme is not of immediate necessity, there may still be unknown negative factors affecting populations and so it should not be totally discounted, particularly as their needs are not as specific as it was once thought. If strongholds are found to have dwindling populations, it still may be of value to initiate a captive breeding programme on the island, to safeguard the species. It should be noted that this would need to consist of individuals from either High Peak or Diana's Peak, or separate populations from each, to maintain any potential genetic distinctiveness unless research in the meantime shows no differences are present.
Monitoring is needed, along with further work on the life history of the species, through dedicated observations and more in depth analysis.
Numbers in the 'Dell' have dwindled drastically even since 2015, with only 12 individuals seen in this apparently prime habitat, posing the question whether that population has experienced a crash, has migrated, there are unperceived changes in the habitat or some other factor. Continued careful monitoring would be beneficial to get a clearer picture of the population structure and mobility in this area, although repeated visits may themselves be negatively affecting conditions. The use of the UV torch has greatly increased detection with less disturbance to the area or individuals, leading the way forward for future monitoring. The Dell should be monitored for the next year to determine changes and action needed.

Future Work

The extent of potential habitat should be identified through comprehensive vegetation mapping, including assessment of quality of habitat, to estimate population extent and viability. The mapping work being undertaken by DPLUS052 will be greatly beneficial to determining conservation actions and target locations in the next few years. High resolution mapping of the Peaks will allow identification of areas which would benefit from management, including where habitat corridors and linkages could be made with reasonable management actions.
Assessment of the health of Tree fern thicket and Black cabbage tree woodland, including their lifecycles and ecological associations would allow for a more comprehensive assessment of the value and condition of the present vegetation.
Further dedicated work on the biology, ecology and habitat of the *P. atlantica* would be a useful PhD project. More time is required for observations throughout the year and strategic surveying expanding on current findings would further improve understanding of the species.
Future work will be able to build on information provided by this project. It is likely that some inferences and assumptions will be altered with new information.

Additional Considerations
It takes time to get to know the Peaks areas and the terrain is steep and tricky. No one should attempt to find *P. atlantica* populations on their own, without a suitably experienced guide. The vegetation is delicate so as well as the possibility of getting lost, damage could be done by inexperienced persons.
P. atlantica is also protected by the St Helena Environmental Protection Ordinance. The appropriate organisation or person should be contacted prior to work being done in this area or on this species.

Conclusions

The Spiky yellow woodlouse is an iconic and striking species that in addition to being important to preserve in its own right, should be utilised as a flagship species for St Helena's cloud forest species and habitat, as well as St Helena itself. The opportunities to promote this species are numerous and dedicated promotion can only be beneficial. In the era of social media, this species is an obvious choice for focus and appeal. This species has been found to be far more numerous that initially feared, but still in pockets of apparently suitable habitat. This highlights the need for further work and investigation into the species of the Peaks, and the preservation of the habitat. There is more work to be undertaken on this species to improve knowledge for its preservation and promotion. This includes further research on the ecology of the species itself, and further research into the dynamics of the cloud forest vegetation. Practical work to maintain, enhance and extend the cloud forest vegetation can only be beneficial.

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